



Original Research Paper

Effect of plant growth regulators and pinching on growth and flower yield of African marigold (*Tagetes erecta* L.)

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ABSTRACT

Marigold is one of the commercially exploited flower crop that belong to the family Asteraceae. Presently, in our country the commercial extraction of marigold carotenoids is becoming popular in many states. The production of economical yield and better quality of marigold flowers, requires proper crop management techniques. Crop regulation and flower forcing are important techniques to make the marigold production profitable. This can be done by adopting pinching and application of PGRs. Hence, an experiment was carried out in the Department of Horticulture, in factorial randomized block design replicated thrice with 14 treatments with two F_1 hybrids viz., Gold Benz tall and Maxima yellow. The experiment comprised of GA_3 @ 50, 100 and 150ppm, NAA @ 50, 100 and 150ppm, MH @ 250, 500 and 750ppm, Alar @ 200, 400 and 600ppm and pinching with untreated control. The study revealed that the growth parameter like plant height, number of laterals per plant, number of leaves per plant were significantly influenced by the application of GA_3 and NAA. Among the varieties, Gold Benz tall performed better for all the growth attributes but var. Maxima yellow performed better for the number of laterals per plant. The plant sprayed with of GA_3 @ 150ppm registered the maximum plant height (70.44cm), number of laterals per plant (16.13), number of leaves per plant (383.76) and leaf area (113.51cm²) and control evinced the least values in the growth parameters. Application of GA_3 and NAA significantly enhanced flowering when compared to control, while pinching delayed flowering. The treatment of GA_3 @ 150ppm in both Gold Benz tall (30.13 and 406.21 g plant⁻¹) and Maxima yellow (33.16 and 402.83 g plant⁻¹) recorded maximum number of flowers per plant and flower yield respectively as compared to control. Based on the above results, it is revealed that foliar spray of GA_3 @ 150 ppm was found to be superior in increasing the yield of flowers in both the varieties.

Keywords: Marigold, growth regulators, GA_3 , NAA, flowering.

INTRODUCTION

Marigold is one of the commercially exploited flower crops that belong to the family Asteraceae and genus *Tagetes*. The two main popularly grown species in marigold are *Tagetes erecta* L. and *Tagetes patula* L. which have their origin in Mexico and South Africa, respectively. Presently, in our country, the commercial extraction of marigold carotenoids is done in Cochin (Kerala), Hyderabad (Andra Pradesh), Satyamangalam (Tamil Nadu) and Telagi near Harihar, Davenagere, Haveri and Kolar, Chikmagalur district and around Bangalore (Karnataka). Consequently large area in Karnataka, Andra Pradesh, Tamil Nadu and Maharashtra are under contract farming of marigold

for xanthophyll extraction. The production of economical yield and better quality of marigold flowers, requires proper crop management techniques. Crop regulation and flower forcing are important techniques to make the marigold production profitable. Growth regulation can be done by adopting pinching and application of PGRs. The response for these practices may vary depending up on the variety cultivated. Plant growth regulators have gained wide acceptance for optimizing the yield of plants by modifying growth, development and stress behavior (Shukla and Farooqi, 1990). Synthetic plant growth regulators, such as auxins, cytokinins and various growth retardants when applied exogenously to the plant, influence various aspects of plant development

and biosynthesis of its important components (Kewalanand and Pandey, 1998). Control of flowering is one of the most important practical aspects in application of plant growth regulators. There are many examples of utilization of plant growth hormones to regulate the flowering in many plants. Hence, the present investigation was undertaken to study the effect of plant growth regulators and special horticultural practice like pinching for increasing yield and quality of flowers.

MATERIAL AND METHODS

The experiment was carried out in Department of Horticulture, Faculty of Agriculture, Annamalai University during the period 2012-2013 to elucidate information on effect of different growth regulators and pinching on growth and yield of marigold. This experiment was carried out in factorial randomized block design replicated thrice with 14 treatments. Two F_1 hybrids namely Gold Benz tall and Maxima yellow were taken for the study with the treatments comprising of GA_3 @ 50, 100 and 150ppm, NAA @ 50, 100 and 150ppm, MH @ 250, 500 and 750ppm, Alar @ 200, 400 and 600ppm, pinching and untreated control. These growth regulators were applied as foliar spray to the respective plots as per treatment schedule in two doses at ten days after planting and twenty days after first spray. Pinching was done at twenty days after transplanting. The growth and yield parameters were recorded at different stages of crop growth (30, 45 and 60 days after transplanting). The statistical analysis of data was done by adopting the standard statistical procedure given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The study revealed that the growth parameter viz., plant height, number of laterals per plant, number of leaves per plant were significantly influenced by the application of growth regulators (**Table 1**). Among the varieties V_1 (Gold Benz tall) performed better for all the growth attributes, however, the number of laterals per plant was recorded highest in V_2 (Maxima yellow). The plant sprayed with GA_3 @ 150 ppm (T_3) registered maximum plant height (70.44 cm) which was followed by GA_3 @ 100 ppm (T_2) (67.46 cm). Similarly, the data on number of laterals per plant (16.13), showed were maximum under GA_3 @ 150 ppm (T_3) which was followed by GA_3 @ 100 ppm

(T_2) with 15.16. Among the growth attributes, plant height and number of laterals per plant were significantly increased as the concentration of GA_3 and NAA increased. The increase in plant height and number of branches per plant with application of GA_3 seems to be due to enhanced cell division and cell enlargement, promotion of protein synthesis coupled with higher dry matter accumulation in the plant. Similar results were also reported by Daddagoudar (2002) in China aster and Dalal *et al.* (2009) in Chrysanthemum.

However, the reduction of plant height in pinched plants is mainly due to elimination of apical dominance and diversion of the plant metabolites from vertical growth to horizontal growth leading to production of more number of branches per plant. As the apical dominance is removed usually the plant itself adjusts to encourage the growth of auxiliary buds, which may be converted into branches. Similar effects were reported by Sen and Naik (1977) in chrysanthemum and Khanna *et al.* (1981) in carnation and Sunitha *et al.* (2007) in African marigold.

The number of leaves per plant also showed similar results with maximum leaves (383.76 / plant) under treatment GA_3 @ 150 ppm (T_3) and largest leaf area (113.51cm²). The control treatment evinced the least values for all the growth parameters. Variation in number of leaves/ plant was pronounced by the application of different growth regulators. The effects of the GA_3 treatments were observed significantly superior to the rest of the treatments. This trend was in concurrence with findings of Narayana Gowda (1985) in China aster and Talukdar and Paswan (1988) in Chrysanthemum.

In general, the yield parameters were significantly varied due to *per se* and interaction effects of growth regulating treatments and varieties (**Table 2**). In the present study, number of days taken for first flowering was significantly altered due to the application of different growth regulators. Pinching hastened the flowering when compared to application of GA_3 , NAA, MH and Alar. The yield parameters are also significantly influenced due to growth regulator and pinching treatments. Application of GA_3 and NAA significantly enhanced flowering when compared to control, while, pinching delayed flowering. Significantly earlier flower initiation were registered

Table.1 Effect of growth regulators and pinching on vegetative characters in African marigold

Treatments	Plant height (cm)		Number of laterals/plant		Number of leaves/ plant		Leaf area/ plant		
	V1	V2	Treatment mean	V1	V2	Treatment mean	V1	V2	Treatment mean
T ₁ – GA ₃ 50 ppm	83.86	38.40	61.13	13.53	14.20	13.86	345.40	312.20	328.00
T ₂ – GA ₃ 100 ppm	91.48	43.44	67.46	14.73	15.60	15.16	377.80	343.33	360.56
T ₃ – GA ₃ 150 ppm	93.56	45.52	70.44	15.53	16.73	16.13	399.40	368.13	383.76
T ₄ – NAA 50 ppm	81.14	37.48	59.31	13.33	14.00	13.66	340.00	308.00	324.00
T ₅ – NAA 100 ppm	86.44	40.46	63.45	14.06	14.60	14.33	359.80	321.20	340.50
T ₆ – NAA 150 ppm	88.40	41.66	65.03	14.33	15.26	14.80	367.00	335.86	351.43
T ₇ – MH 250 ppm	74.48	33.58	54.03	12.20	13.06	12.63	310.73	287.46	299.10
T ₈ – MH 500 ppm	70.66	30.62	50.64	10.93	11.46	11.20	300.26	240.53	270.40
T ₉ – MH 750 ppm	67.04	28.47	47.76	10.53	10.80	10.66	288.93	231.73	260.33
T ₁₀ – Alar 200 ppm	76.44	36.48	55.46	12.66	13.60	13.13	322.00	299.20	310.60
T ₁₁ – Alar 400 ppm	73.56	32.47	53.02	11.46	11.80	11.63	302.60	255.20	278.90
T ₁₂ – Alar 600 ppm	67.83	29.49	48.66	10.60	11.40	11.00	299.80	233.20	266.50
T ₁₃ – Pinching	65.39	26.58	45.98	9.73	10.53	10.13	284.40	214.13	249.26
T ₁₄ – Control	78.25	35.54	56.89	9.13	9.60	9.36	246.60	211.20	228.90
Variety Mean	78.59	35.58	57.09	12.53	12.85	12.69	324.62	282.97	303.79
	SEd	CD(p=0.05)		SEd	CD(p=0.05)		SEd	CD(p=0.05)	
V	0.02	0.04		0.33	0.66		0.78	1.57	
T	0.06	0.12		0.08	0.17		2.07	4.16	
V x T	0.09	0.18		0.12	0.24		2.93	5.88	
							0.34	0.68	
							0.90	1.80	
							1.27	2.55	

Table.2 Effect of growth regulators and pinching on flowering and yield characters in African marigold

Treatments	Days taken for flower appearance			Number of flowers per plant			Single flower weight (g)			Flower yield per plant (g)			Xanthophyll content (mg g ⁻¹)		
	V1	V2	Treatment mean	V1	V2	Treatment mean	V1	V2	Treatment mean	V1	V2	Treatment mean	V1	V2	Treatment mean
T ₁ – GA ₃ 50 ppm	38.20	39.66	38.93	26.60	28.40	27.50	12.07	10.96	11.51	321.06	311.26	316.16	5.77	5.73	5.75
T ₂ – GA ₃ 100 ppm	33.20	34.40	33.80	28.26	31.20	29.73	13.07	11.96	12.51	373.15	369.35	371.25	6.56	6.52	6.54
T ₃ – GA ₃ 150 ppm	31.40	32.40	31.90	30.13	33.16	31.80	13.37	12.25	12.81	406.21	402.83	404.52	6.77	6.73	6.75
T ₄ – NAA 50 ppm	40.00	41.46	40.73	26.53	28.00	27.26	11.76	10.68	11.22	311.99	299.04	305.51	5.58	5.54	5.56
T ₅ – NAA 100 ppm	36.00	37.53	36.76	27.80	29.20	28.50	12.37	11.27	11.82	343.88	329.08	336.48	5.95	5.90	5.93
T ₆ – NAA 150 ppm	35.20	36.93	36.06	28.00	30.53	29.26	12.77	11.66	12.21	357.56	355.97	356.76	6.17	6.13	6.15
T ₇ – MH 250 ppm	42.00	43.46	42.73	24.20	26.13	25.16	9.98	8.84	9.41	241.51	230.98	236.24	4.58	4.54	4.56
T ₈ – MH 500 ppm	45.40	47.86	46.63	21.86	23.53	22.70	10.76	9.66	10.21	235.21	227.29	231.25	4.98	4.93	4.96
T ₉ – MH 750 ppm	48.40	50.26	49.33	21.06	22.20	21.63	11.46	10.36	10.91	241.34	229.99	235.66	5.38	5.34	5.36
T ₁₀ – Alar 200 ppm	41.00	42.60	41.80	24.40	27.20	25.80	9.66	8.53	9.09	235.70	232.01	233.85	4.38	4.34	4.36
T ₁₁ – Alar 400 ppm	43.20	45.73	44.46	22.93	23.80	23.36	10.47	9.37	9.92	240.07	223.00	231.53	4.78	4.74	4.76
T ₁₂ – Alar 600 ppm	47.40	49.66	48.53	21.33	23.46	22.40	11.06	9.93	10.49	235.90	232.95	234.42	5.19	5.15	5.17
T ₁₃ – Pinching	52.60	54.46	53.53	19.46	22.13	20.80	9.16	8.07	8.61	178.58	178.25	178.41	4.08	4.04	4.06
T ₁₄ – Control	50.20	52.40	51.30	18.46	19.20	18.83	9.13	8.04	8.58	168.53	154.36	161.44	4.07	4.03	4.05
Variety Mean	41.72	43.49	42.60	24.96	25.71	25.34	11.22	10.11	10.67	277.37	270.27	273.82	5.30	5.26	5.28
	SEd	CD (p=0.05)		SEd	CD (p=0.05)		SEd	CD (p=0.05)		SEd	CD (p=0.05)		SEd	CD (p=0.05)	
V	0.08	0.17		0.07	0.14		0.03	0.05		0.18	0.36		0.003	0.007	
T	0.23	0.47		0.18	0.37		0.05	0.09		0.34	0.69		0.010	0.020	
V x T	0.33	0.67		0.26	0.53		0.07	0.14		0.54	1.05		0.014	0.029	

(V1-Goldbenz Tall/v2-Maxima Yellow)

in the plants sprayed with GA_3 @ 150 ppm in Gold Benz tall (31.40 days) and 32.40 days in Maxima Yellow. However, it was delayed in the plants sprayed with MH @ 750 ppm and Alar @ 600 ppm. Thus, it is evident that the days taken for flower initiation were delayed significantly by spraying growth retardants. In general, it is concluded that GA_3 @ 150 ppm promoted flowering in both Gold Benz tall (31.40 days) and Maxima yellow (32.40 days). This might be due to synergetic effect of auxins with gibberellins generally obtained in short day plants. The delayed flowering in marigold with the application of MH might be due to lesser mitotic activity and preservation of biosynthesis of gibberellic acid like substances. The present results are in agreement with the findings of Sen and Maharana (1971) and Dutta *et al.* (1993) in chrysanthemum.

The treatment of GA_3 @ 150ppm in both Gold Benz tall (30.13 and 406.21 g) and Maxima yellow (33.16 and 402.83 g) recorded maximum number of flowers per plant and flower yield per plant as compared to control. The plant sprayed with of GA_3 @ 150ppm registered the maximum number of flowers per plant (31.80) and flower yield per plant (404.52 g) as compared to control. The increase in number of flowers might be due to production of large number of laterals at early stage, which had sufficient time to accumulate reserve carbohydrates for proper flower bud differentiation.

The increase in flower yield by GA_3 @ 150 ppm treatment was due to increased number of branches

which led to increased number of flowers and improvement in individual flower weight. These findings are in accordance with Kumar and Ugherja (1998), Gupta and Dutta (2000), Rakesh *et al.* (2003) and Singhrot *et al.* (2004) in chrysanthemum.

Among all interaction treatments, V_1T_3 (Gold Benz tall GA_3 @150 ppm) recorded the highest yield (406.21 g) per plant followed by V_2T_3 (Maxima yellow GA_3 @ 150 ppm) (402.83 g) per plant. The gibberellin is well known for its promoter effects on cell division and cell elongation. Therefore an increase in single flower weight obtained with the application of GA_3 @ 150 ppm might be due to increase in GA activity in the floral buds. Since, the alar is an anti-auxins and also possibly anti-gibberellins too would have reduced the flower size and stalk length. Similar results were also reported by Girwani *et al.* (1990), Gowda and Jayanthi (1991) in marigold, Vijai Ananth and Anburani (2010) and Kumar and Haripriya (2010) in nNerium and Ragaa and Taha (2012) in iris.

Marigold flower production is governed by the extent of which the applied growth regulators are translocated to these floral parts to obtain higher yield of flowers and ultimately xanthophyll yield. Xanthophyll yield was maximum with the treatment GA_3 @ 150 ppm and minimum in control (T_{14}). Based on the above facts and results of the present studies on growth regulator treatments and pinching on different varieties of marigold, it is revealed that foliar spray of GA_3 @ 150 ppm was found to be superior in increasing yield of flowers in both varieties.

REFERENCES

- Daddagoudar, S. R., Vyakaranahal, B. S., Shekhargouda, M., Nalini Prabhakar, A. S. and Patil, V.S., 2002. Effect of mother plant nutrition and chemical spray on growth and seed yield of China aster cv. Kamini. *Seed Research*, **30(2)**: 269-274.
- Dalal.S.R., Karale, G.D. and Kalkame Momin,C.H. 2009. Effect of growth regulators on growth, yield and quality of Chrysanthemum under net house conditions. *Asian. J. Hort.*, **4 (1)**: 161-163.
- Dutta, J.P., R. Seemanthini and Khader, M.A. 1993. Regulation of flowering by growth regulators in chrysanthemum (*Chrysanthemum indium* L.) cv. Co-1. *South Indian Hort.*, **41(5)**: 293-299.
- Girwani, A., Baba, R.S. and Chandrashekhar, R. 1990. Response of marigold (*Tagetes erecta* L.) to growth regulators and zinc. *Indian Agric.Sci.*, **60(3)**: 220-222.
- Gowda N.J.V., and Jayanthi,R. 1991. Effect of CCC and MH on growth and flowering of African marigold (*Tagetes erecta* L.). *Prog. Hort.*, **23 (1-4)**: 114 – 118.

- Gupta, V. N. and Datta, S.K. 2000. Influence of GA₃ on growth and flowering in chrysanthemum (*Chrysanthemum morifolium* ramat.) cv. Janthi. *Indian J. Plant Physiol.* **6**(4): 420-422.
- Kewalanand, J.N and Pandey, C.S. 1998. Effect of plant growth regulators on the growth, herbage and oil yield of Japanese mint (*Mentha arvensis*) and its economic there from. *J. Med. Arom Plant Sci.*, **20**: 725 – 730.
- Khanna, K., Arora, J. S. and Singh, J., 1981. Effect of spacing and pinching on growth and flower production of carnation (*Dianthus caryophyllus* cv. Marguerite Scarlet). *J. Orn. Hort.*, **5**(1-2): 16-19.
- Kumar, S., and Haripriya, K. (2010). Effects of growth retardants on growth, flowering and yield of Nerium (*Nerium odorum* L.). *Plant Archives.*, **10**(2) : 681 – 384.
- Kumar, K.K. and Ughreja, P.P. (1998). Effect of foliar application of GA₃, NAA, MH and Ethereal on growth, flowering and flower yield of chrysanthemum (*Chrysanthemum morifolium*) cv. IIHR-6. *J. Applied Hort.*, **4**(1-2): 20-26
- Narayana Gowda, J. V., 1985. Investigation on horticultural practices in the production of China aster (*Callistephus chinensis* L. Nees). Ph.D., Thesis, University of Agricultural Sciences, Bangalore.
- Panase, V.G. and Sukhatme, P.V., 1967. Statistical methods for agricultural workers, ICAR, New Delhi. p. 381 (1967).
- Ragaa A. and Taha, 2012. Effect of some growth regulators on growth, flowering, bulb productivity and chemical composition of Iris plants. *J. Hort. Sci. & Orn. Plants*, **4** (2): 215 – 220.
- Rakesh, Singhrot, R.S., and Beniwal, 2003. Effect of GA₃ and pinching on growth and yield in chrysanthemum. *Haryana J. Hort. Sci.*, **32**(1&2): 61-63.
- Sen, S.K. and Maharana, T. (1971). Growth and flowering response of chrysanthemum to growth regulator treatments. *Punjab Hort. J.*, **11**: 276-279.
- Sen, S.K. and Naik, J., 1977. Growth and flowering response of pinched and unpinched chrysanthemum to growth regulator treatment. *Indian J. Hort.*, **33**: 86-90.
- Shukla, A and A.H. Farooqi, 1990. Utilization of plant growth regulators in aromatic plant production. *Curr. Res. Med. Arom. Plants*, **12**: 152 – 157.
- Singhrot, R.S., Beniwal, B.S. and Moond, S.K. 2004. Effect of GA₃ and pinching on quality and yield of flowers in chrysanthemum. *J. Hort. Sci.*, **32** (1&2): 224-226.
- Sunitha, H.M., Ravi Hunje, B.S., Vyakaranahal and H.B. Bablad. 2007. Effect of plant population, nutrition, pinching and growth regulators on plant growth, seed yield and quality of African marigold (*Tagetes erecta* Linn.). *J. Orn. Hort.*, **10**(2): 90-95
- Talukdar MC, Paswan L (1988). Effect of GA₃ and CCC on growth and flowering of standard chrysanthemum. *J. Orn. Hort.*, **1**: 11-16.
- Vijai Ananth, A and Anburani, A. (2010). Effects of growth retardants on growth and yield in nerium (*Nerium odorum* L.). *J. Orn. Hort.*, **13** (3): 240 - 242.

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